

Gellish Modeling Method

Part 5

Modeling of activities, processes and state changes including their presentation in diagrams

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Table of Content

1	Introduction	2
2	Specification of activities, processes and events.....	2
2.1	Sequences of activities.....	3
2.2	Relations between physical objects and activities	4
2.3	Graphical representation	5
3	Physical objects involved in activities	6
3.1	Properties of physical objects	6
3.2	Physical objects subjected to activities	6
4	Sequences of activities	8
5	Duration, begin and end, where and when.....	9
6	Cause and effect.....	9
7	States and state changes.....	10
8	Scope and lay-out of diagrams of activities	11
8.1	Selection of activities and physical objects via schematic diagrams	12
9	References	12

1 Introduction

This document describes how activities, processes and events with sequences of occurrences and their involved physical objects together could be modelled in semantic models and how they should be expressed in Gellish English or another Gellish language variant. It also includes guidelines on how to model states and state changes of object. This document also indicates how diagrams, such as PFS's (process flow schemes), IDEF0 diagrams¹ and WFS's (work flow schemes), which are graphical presentations of process models or activity models, could be generated from the models. It includes also the reverse process: when an activity model is created or modified graphically, this document indicates how the resulting activity model should be produced in Gellish.

The term activity in this document stands for any occurrence, including also processes and events, which may be business processes as well as biological, physical or chemical processes and events.

This document should be read in conjunction with other parts of the Gellish Modeling Method and the Gellish language definition documentation, including:

- The Definition of Gellish Universal Databases and Exchange Messages
- The Gellish Dictionary - Taxonomy, especially the TOPini section
- Gellish Modeling Method
 - Part 1, Architecture. This part describes an overall architecture for information and its management.
 - Part 2, Creation of Domain Dictionaries - Taxonomies.
 - Part 3A, Knowledge Modeling (Creation of Ontologies).
 - Part 3B, Requirements Modeling. About general requirements, standard specifications and product catalogues.
 - Part 4, Creation and Use of Facility Information Models'', focuses on the creation of models with primarily 1D data and their integration with documents.
 - *Part 5, Modeling of Activities and Processes*. This part. It specifies how occurrences are modelled, together with the involved parties and objects.
 - Part 5A, Measurements and Observations.
 - Part 6, Creation of Facility and Product Models.
 - Part 7, General Principles and Guidelines.
 - Part 8, Product Modeling in 1D, 2D and 3D. How to integrate data, schematic drawings and 3D models.
 - Part 9, Modeling of Measurements and Observations.

2 Specification of activities, processes and events

An activity, process or event (an occurrence) is an interaction between various physical objects that are involved in the occurrence. We distinguish between *individual occurrences* and *kinds of occurrences*. Any occurrence or kind of occurrence is represented by a unique identifier, the Gellish UID, and is denoted by a name (and optionally one or more synonyms or aliases).

¹ <http://en.wikipedia.org/wiki/IDEF0>

Each individual occurrence shall be defined by classified by at least one <is classified as (a)> relation and have a textual definition. For example, a project to construct a building is a complex process that can be classified as building or as a building process. An example of the expression of such a fact is the following expression:

Project X <is classified as> building

In this expression the concept ‘building’ is an individual process to build a particular building² that is classified by a kind of process, being ‘building’.

Each kind of occurrence shall be defined by at least one <is specialisation of> relation that specifies what its supertype kind of occurrence is. This specialization relation shall be accompanied by a textual description of the concept that further defines what is meant by such a kind of occurrence. These ‘definition models’ should be included in a domain Dictionary-Taxonomy, that also records what its unique identifier in Gellish is. An example of such a specialization relation and textual definition is the following Gellish expression:

building is a specialization of process to produce a physical building from raw materials.

The definition model may also include the fact that the kind of activity has by definition a particular kind of physical object as its subject. For example:

building has by definition as subject a building

Note that the formal Gellish version of the latter expression uses two different UID’s to denote and distinguish the building activity and the physical building respectively.

Kinds of occurrences can have various syntactic forms. For example, a particular activity may be classified for example as an ‘inspection’ or as ‘inspecting’ or as ‘to inspect’. All those inflections mean the same, semantically it does not matter whether a noun or a verb is used to classify the activity³. Therefore, these terms are indicated as synonyms in a Gellish semantic dictionary.

The creation of a domain Dictionary-Taxonomy with these kinds of definition models is further discussed in the Gellish Modeling Method - Part 2.

2.1 Sequences of activities

An activity topology or sequence of activities is typically described in one of two ways:

1. By specifying that a physical object that is output from one activity is input in a next activity.
2. By specifying that one activity is performed after another, and optionally specifying separately which physical objects are involved in each of the activities.

The first method is used for example as the basis for the IDEF0 activity modeling method. The second method is used for example as the basis for the Work Flow Schemes (WFS), which are used to schedule and present activity sequences for example for commissioning and start up processes of new facilities or for turnaround processes (shut down, maintenance, commissioning and start up) of existing facilities.

These sequences of activities can be specified for sequences of individual activities or as sequences of kinds of activities in general. Sequences of individual activities are for examples descriptions of measurements and observations that actually took place (see also Part 9, Modeling of Measurements

² The term building has two meanings (homonyms): the building activity and the resulting physical object. Homonyms are different concepts in Gellish, distinguished by different unique identifiers (UID’s).

³ Semantically there is a difference in time, because inspecting typically indicates an ongoing process. However, in Gellish the tense is irrelevant, as the time that a fact or occurrence takes or took place or will take place is recorded separately through the time of begin and end of existence or validity of the fact or occurrence.

and Observations, Ref. 3), it can also be an example of a typical individual process, such as a procedure that is described as an individual process that should be repeated by copying. However, in most cases sequences of activities are general sequences between kinds of activities. For example, maintenance or usage instructions about all individual objects of a particular type.

The specification of both ways to express sequences are described below.

2.2 Relations between physical objects and activities

Physical objects or *kinds of physical objects* can play roles in the activities. Therefore, physical objects that are involved in activities are related to those activities by kinds of relations that imply those roles.

Examples of physical objects are: buildings, factories, roads, vehicles, equipment, instruments, pipes, streams, signals, electronic files, organizations, persons, etc.

The kinds of relations that are used in Gellish to express that and how physical objects are involved in individual activities are all subtypes of the relation type <is involved in>. A number of them are illustrated in Figure 1.

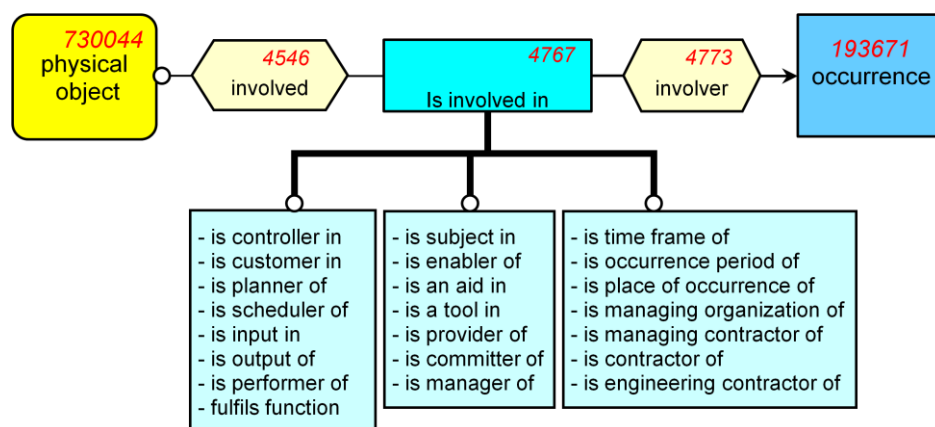


Figure 1, kinds of involvements of individual physical objects in individual occurrences

The relations between activities and physical objects that are used in IDEF0 diagrams are described in Gellish as follows:

activity	<has as input>	physical object
activity	<has as output>	physical object
activity	<is controlled by>	physical object
activity	<uses as mechanism>	physical object
activity	<has as subject>	physical object

Equivalent kinds of relations that are used to classify relations between kinds of activities and kinds of physical objects that describe knowledge about possibilities are the following:

kind of activity	<can have as input a>	kind of physical object
kind of activity	<can have as output a>	kind of physical object
kind of activity	<can be controlled by a>	kind of physical object
kind of activity	<can use as mechanism a>	kind of physical object
kind of activity	<can have as subject a>	kind of physical object

It is also possible to specify that one or more of the above kinds of relations may be constrained to a requirement that is only applicable in a particular context. In that case the Gellish phrases begin with <shall ...> instead of <can ...>. For example:

pumping <shall have as input a> stream of liquid

Some kinds of activities have relations that are by definition the case. Such activities are defined by relations where the Gellish phrase begins with <is/has by definition ...> instead of <can ...>. For example:

water treatment <has by definition as input a> stream of water

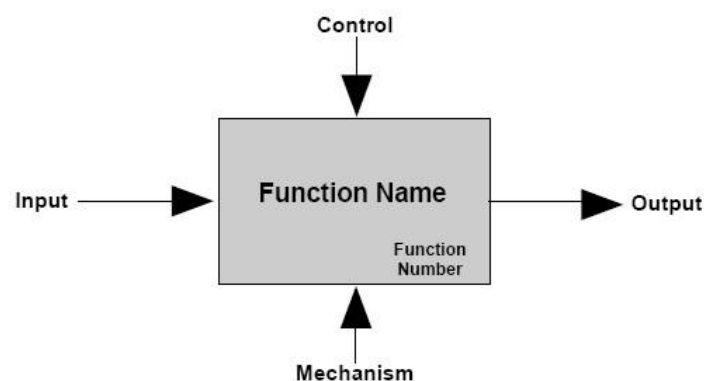
A physical object or kind of physical object can have a kind of role in these relations that either an Input, Output, Controller, Mechanism (with its subtypes performer, enabler or aid) or Subject.

Note, a kind of relation may also be a subtype of one of the above kinds of relations and a kind of role may also be a subtype of one of the above kinds of roles. Standard subtypes are available from the Gellish Dictionary.

2.3 Graphical representation

In an **IDEF0 Diagram** an activity or kind of activity is denoted by a rectangular **Process box**:

- The name of the activity and optionally its code (alias, when available) is written in the box. The size of the boxes on a page shall be identical and not less than 10x15 mm, and depends on the size of the wrapped text. The character size of the text shall be selectable once for all pages.
- The activity is often denoted as the ‘function’ being the activity or process that is performed by or enabled by (= the function of) the mechanism. Thus a process box is usually depicted as follows:



In IDEF0 diagrams physical objects are represented by **Process connectors (lines)**.

- Each Process connector connects a box with another box or with the outside ‘world’ (the edge of a page). Each connector has a direction from output to input and an arrow at the end that represents an input, control, mechanism or subject.
- Each Process box has various ‘ports’. A port is a physical point that can act as a connect point for a Process connector on a Process box symbol. In IDEF0 diagrams ports are located at the middle of the sides of each Process box.

A Process connector (physical object or kind of physical object) starts or end at a specific port on a Process box, dependent on its kind of role towards the activity (and thus dependent on its kinds of relation):

- An Input ends at a Process input port at the left hand side of a Process box.
- An Output starts at a Process output port at the right hand side of a Process box.

- A Controller ends at a Process control port at the upper side of a Process box.
- A Mechanism (or one of its subtypes performer, enabler or aid) ends at a Process mechanism port at the lower side of a Process box.
- A Subject end at a Process input port at the left hand side of a Process box and also starts at a Process output port at the right hand side of the same Process box.

In WFS diagrams physical objects are indicated by *Physical object boxes* at the left hand side of the diagram. They represent the physical object (e.g. a system) that is subjected to the various activities.

3 Physical objects involved in activities

3.1 Properties of physical objects

Each physical object that plays a role in an activity can be defined in the form of a product model, just as any other physical object. Details of such a specification are described in the Ref. 2.

Normally the roles in an activity are played by different physical objects, whereas each of them has its own composition and properties.

For example, a wall is fabricated from a batch of concrete, whereas the batch as well as the wall each has its own properties.

This is described as follows:

concrete casting	<has by definition as input a>	batch of concrete
concrete casting	<can have as output a>	concrete wall
batch of concrete	<shall have as aspect a>	volume
concrete wall	<is a specialization of>	wall
wall	<shall have as aspect a>	height
wall	<shall have as aspect a>	width
wall	<shall have as aspect a>	thickness

etc.

Note that the fourth line, on which it is specified that a concrete wall <is a specialization of> wall, is already included in the Gellish Dictionary/Taxonomy and implies that the facts about a wall are inherited by a concrete wall. Thus the requirements that a wall shall have a height, a width and a thickness (as is specified for example in the three lines below that line) are inherited by a concrete wall.

3.2 Physical objects subjected to activities

Sometimes an activity ‘operates on’ a physical object, which means that the physical object has a role as input has also a role as output of the same activity. In addition to that, that same physical object will also be an input and an output of another activity. This means that the physical object has two times a role as input and two times a role as output. The specification of the topology of such a process might be ambiguous. Such a situation can unambiguously be expressed in Gellish in any of the following two methods:

- 1) By expressing that the physical object <is subject in> the activity. This means that the activity ‘operates on’ the physical object, whereas the physical object before and after the activity is the same physical object.
- 2) By distinguishing the pre-state and the post-state of the physical object as separate states (‘temporal parts’) of the physical object. This means that the pre-state and the post-state of the physical object are defined as different ‘objects’, each with its own aspects (properties),

although the whole and the parts share aspects that are not redefined per state. The relation between the whole physical object S1 and its states St1 and St2 is expressed by the relation type as is illustrated in the following expression:

Pre-state St1 <is a state of physical object> S1

The difference between the two methods is clarified using the example process in Figure 2.

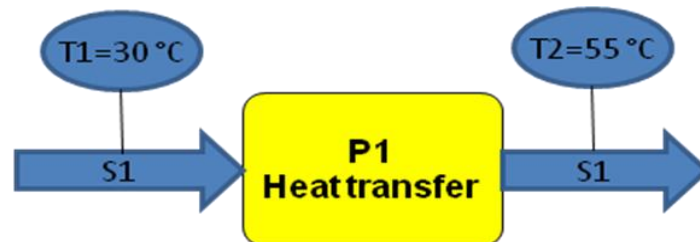


Figure 2, A heat transfer process

The example of Figure 2 illustrates that a stream S1 is input a heat transfer process P1, whereas in the state St1 before being heated the stream has a temperature T1 of 30 deg C. The same S1 is output of that process, but in a heated state St2, whereas its temperature T2 is 55 deg C after being heated.

In the first of the two modeling methods to describe the process there is only one physical object S1 that ‘passes through’ the activity and that possesses all properties before as well as after the activity. This means that the activity P1 ‘operates on’ S1, which is specified as follows:

S1 <is subject in> P1

Or by using the inverse phrase for the same kind of relation:

P1 <has as subject> S1

For kinds of activities on kinds of physical objects this would be:

stream <can be subject in a> heat transfer process

In case of a batch process, T1 occurs earlier than T2. Therefore, the fluid can be defined to have one temperature (T of S1) that varies over time and that is quantified by different values at different moments in time.

This can be specified as follows:

S1	<has as aspect>	T of S1		
T of S1	<is classified as a>	temperature		
T of S1	<has on scale a value equal to>	30	degC	at 10.50 h
T of S1	<has on scale a value equal to>	55	degC	at 11.30 h

In such a case the temperature ‘T of S1’ typically means the (average) temperature of the whole batch of fluid (a physical object), which temperature is independent of a location in the physical object.

However, it may be required to record that the heated object has a temperature distribution varying by location (at the same moment in time). This is also the case in a continuous process in which a part of the fluid is not yet heated and another part of the fluid is already heated. This means that the temperatures upstream and downstream of the heating process are temperatures at different locations. Typically they are both measured continuously, thus both at the same time. In those cases it is required to define either different temperatures at different locations, or different parts of the fluid, each part with its own temperature. For example, different temperatures at different locations are defined as follows:

S1	<has as aspect>	T of S1 at inlet
S1	<has as aspect>	T of S1 at outlet
T of S1 at inlet	<is classified as a>	temperature
T of S1 at outlet	<is classified as a>	temperature
T of S1 at inlet	<has on scale a value equal to>	30 degC at 11.30 h
T of S1 at outlet	<has on scale a value equal to>	55 degC at 11.30 h

Note that in the above example the two temperatures are both measured at the same time.

The second method to describe the process implies that there are two different ‘objects’ involved, each of which possesses its own aspects. This is done by distinguishing the stream as it is in the pre-heated state from the stream as it is in the heated state. This is done by defining two ‘states’ of the stream, whereas one has a role as input and the other has a role as output. This is specified as follows:

cold S1	<is a state of physical object>	S1
heated S1	<is a state of physical object>	S1
cold S1	<is an input in>	P1
heated S1	<is an output of>	P1

In this second method the two states of the physical object each have their own properties.

For example:

cold S1	<has as aspect>	T of cold S1
T of cold S1	<is classified as a>	temperature
T of cold S1	<has on scale a value equal to>	30 degC at 11.30 h
heated S1	<has as aspect>	T of heated S1
T of heated S1	<is classified as a>	temperature
T of heated S1	<has on scale a value equal to>	55 degC at 11.30 h

The definition of a ‘physical object in a state’ implies that the aspects of the physical object as a whole are also aspects of the states, as long as they are not superseded by the aspects of the state. For example, if S1 has a pressure of 3 bar, whereas for the states there is no pressure specified, then cold S1 as well as heated S1 are assumed to have a pressure of 3 bar.

Both models of the activity shall result in identical diagrams that represent the process, such as in IDEF0 diagrams or PFS’s (process flow schemes).

4 Sequences of activities

The sequence of activities in an IDEF0 diagram follows from the roles of the physical objects in the activities.

However, the sequence may also be specified explicitly. If both kind of data occur, then the explicit specification is dominant over the derived specification.

An explicit activity sequence is specified as follows:

A2	<occurs after>	A1
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and for the kinds of activities:

tightness test	<can occur after a>	cleaning
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Whereas also subtypes and inverse phrases of those relation types may appear (for example <occurs before> or <shall occur after a>).

5 Duration, begin and end, where and when

Activities typically have a particular duration and a date-time of begin and end.

A duration of an occurrence is an aspect that is possessed by the activity. It is recorded as follows:

A1	has as aspect	T1
T1	is classified as a	duration
T1	is quantified on scale as equal to	50 min

The location where something began, or will begin or end is always modeled in the present tense, whereas from the time aspect it should be concluded whether the begin or end is in the past, present or future. The model is as follows:

A1	is beginning at location	place A
A1	is ending at location	place B

There are various ways in which activities can be related to time:

An activity can

- begin or end at a point in time (which may be indicated by a period in time, such as a minute)
- happen within a period of time (somewhere within that period, for example on a particular day)
- happen during a specific period of time, from the start to the end of the period.

The various relations between the occurrence and the time require different kinds of relationships as is illustrated in Figure 3.

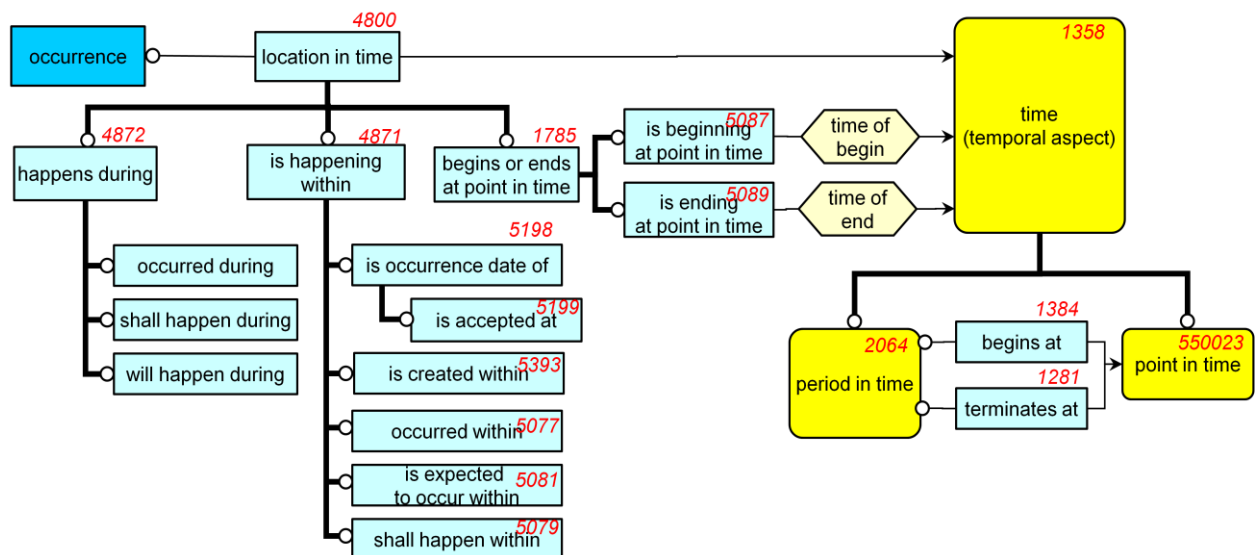


Figure 3, Relations between occurrences and time

6 Cause and effect

Usually we say that an occurrence is initiated (caused or triggered) by another occurrence. However, more precise it may be that the occurrence (or its beginning or ending) triggers the creation (start) or termination (end) of the other occurrence. This means for an accurate modeling of causes and effects that we need to distinguish between an occurrence (activity, process or event) and its creation process and its termination process, which both are parts of the occurrence. Then we can express also that a

creation or termination (that is part of an occurrence) is initiated by the creation or termination process of the same or another occurrence. These variations are illustrated in Figure 4.

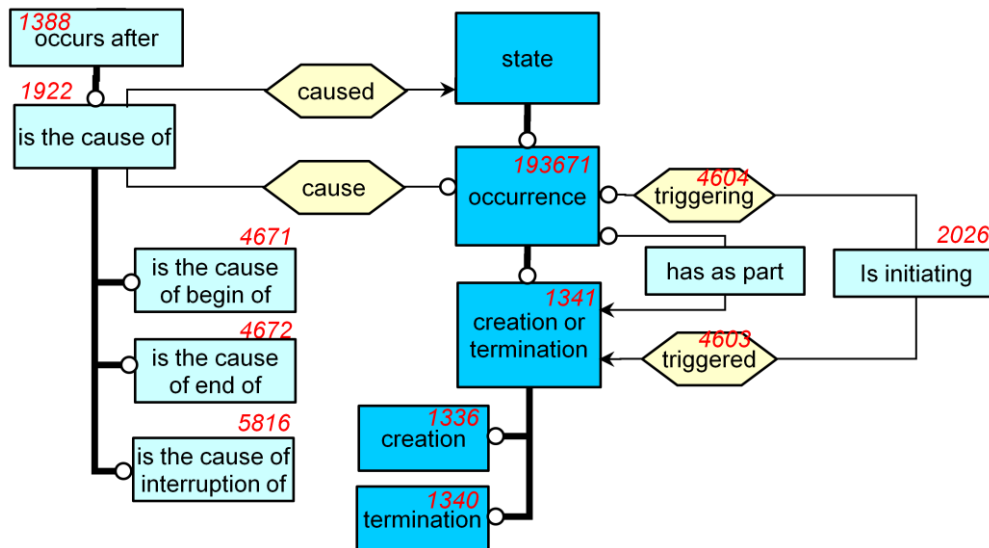


Figure 4, Kinds of relations to model cause and effect

Figure 4 illustrates that an occurrence or one of its subtypes (a creation or termination) can cause a state or one of its subtypes (typically another occurrence). This can be refined by using one of the subtypes of <is the cause of>, to express that an occurrence is the cause of the begin or end or interruption of a state or occurrence. The figure also illustrates that a creation or termination may be initiated or triggered by an occurrence, without being its cause.

7 States and state changes

States can be static as well as dynamic. Static states are states that are described by aspects with values that do not change over time. Dynamic states are typically transitions from one steady state to another, but they can also be continuous changing processes or occurrences. A special kind of dynamic state is a steady state, which is for example a fluid flowing with constant flow rate, or a train driving at constant speed. In steady state processes most aspects do not change, but the total volume transported or the position of the moving object is changing with a constant rate.

The modeling of states and state changes is illustrated in Figure 5.

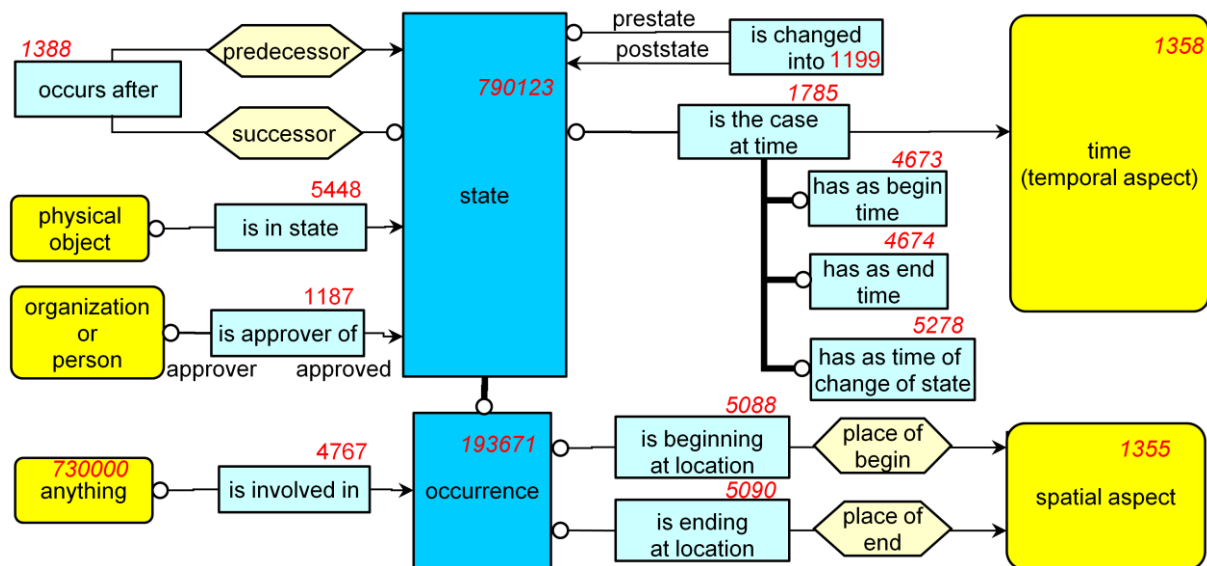


Figure 5, Model of states and state changes

Figure 5 shows that it can be specified that a physical object is in a state (which is called a temporal part in ISO 15926-2). For each state it can be expressed

- when the state begins
- where the state begins
- where the state ends
- when the state ends
- what the sequence of states is,
- which state change took place
- when a (sudden) state change took place

These possible expressions are also possible for each occurrence, because an occurrence is a subtype of a state.

8 Scope and lay-out of diagrams of activities

Activities can be decomposed.

- In Gellish each activity composition between individual whole and one of its part is expressed by a <is a part of> or its inverse <has as part> relation. A conceptual composition relation between a kind of activity and a kind of part is expressed by a <can be a part of a> relation or its inverse <can have as part a> relation.

A root diagram shall be created for a selected activity and lower level diagrams shall be created for the components of that activity.

- In IDEF0 the components of an activity are presented on a new (lower level) diagram. If the number of activities exceed the maximum that fits on a page, then additional sheets shall be created, indicated as 'page x, sheet 1 of n' etc. (within the page).
- In a WFS the components of an activity are presented on a new (lower level) diagram. The size of a WFS sheet is bound to a maximum (typically A0). If the number of physical objects about which activities are recorded, and that thus determine the number

of rows on a diagram, exceed the maximum that fits on a sheet (60) or the number of activities on any of the rows exceed the maximum, then additional sheets shall be created, indicated as ‘page x, sheet 1 of n’ etc. (within the page).

- In a WFS all activities on a row are about the same physical object. The sequence of physical objects is by default determined by the sequence in which the physical objects are defined by a classification or specialization relation in the Gellish Data Table.

8.1 Selection of activities and physical objects via schematic diagrams

Pointing to a box or a symbol (lines, boxes) that represents an activity or a physical object should imply that the software identifies the represented object by searching for the coordinates of the symbol or text that is closest to the coordinates of the pointing device. Then the software should put that ‘object’ in focus and present facts about that object, including also documents about the object. The way to model how documents are related to activities or physical objects is described in the Gellish Modeling Method, part 4 (ref. 2).

9 References

1. IDEF0: <http://en.wikipedia.org/wiki/IDEF0> and www.idef.com.
2. Gellish Modeling Method – Part 4, Facility Information Management. Available via www.gellish.net.
3. Gellish Modeling Method – Part 9, Measurements and Observations. Available via www.gellish.net.